SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING SEPTEMBER, 1917.

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(Dated: Washington, D. C., Nov. 3, 1917.)

For a description of instrumental exposures and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1917, **45**:2.

As noted in the REVIEW for May, 1917, the Marvin pyrheliometer in use at Santa Fe became defective about the beginning of that month, due to an accident. It has been replaced by Marvin silver-block pyrheliometer No. 2 and comparisons between the latter and Smithsonian silver-disk No. 1, made at Santa Fe in October, 1917, indicate that the two instruments are in accord. The Santa Fe data are therefore resumed with this issue.

The monthly means and departures from normal values given in Table 1 show that direct solar radiation averaged about normal at Santa Fe, N. Mex., above normal at Washington, D. C., and Madison, Wis., and below normal at Lincoln, Nebr.

Noon intensities of 1.49 at Washington, D. C., on the 11th and 1.45 at Madison, Wis., on the 10th exceed by about 3 per cent and 2 per cent, respectively, the previous noon intensities at those stations.

There were no half-day series which warranted extrapolation to zero air mass.

Table 3 shows a slight excess of radiation for the month at Madison and a decided deficiency at Washington.

Skylight polarization measurements made at Washington, D. C., on 6 days give a mean of 59 per cent with a maximum of 66 per cent on the 26th. The measurements obtained at Madison, Wis., on 7 days give a mean of 66 per cent with a maximum of 76 per cent on the 10th. This latter is unusually high but is comparable with the high direct radiation intensity obtained on that date.

TABLE 1.—*Solar radiation intensities during September, 1917.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Sept. 4	1.17	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	.....	.....	0.90	.....	.....	.....	.....	.....	.....	.....
11	1.53	1.39	1.26	1.20	1.13	1.07	1.00	0.96	.....	.....
12	1.44	1.25	1.09	0.98	0.89	0.82	.....	.....	.....	.....
13	1.34	1.22	1.11	0.99	0.88	0.80	0.75	0.69	0.62	.....
17	1.43	1.28	1.17	1.07	0.98	.....	.....	.....	.....	.....
18	1.37	1.31	1.20	1.12	0.98	0.83	0.75	0.69	0.64	0.60
19	.....	1.10	0.96	.....	.....	.....	.....	.....	.....	.....
22	.....	1.32	.....	.....	.....	.....	.....	.....	.....	.....
26	.....	1.30	1.21	1.12	1.04	.....	.....	.....	.....	.....
Monthly means	1.38	1.27	1.11	1.08	0.98	0.88	0.83	0.78	(0.63)	(0.60)
Departure from 9-year normal	+0.05	+0.06	+0.03	+0.08	+0.08	+0.07	+0.11	+0.12	−0.03	−0.04
P. M.										
Sept. 11	.....	1.40	1.29	1.20	1.13	1.07	0.98	0.91	.....	.....
12	.....	1.24	0.99	0.86	0.76	0.66	0.59	0.53	0.48	.....
17	.....	1.30	1.14	1.00	0.91	0.84	0.79	0.74	0.68	.....
26	.....	1.22	1.09	0.99	0.90	0.85	0.80	0.72	0.62	0.54
Monthly means	.....	1.29	1.13	1.01	0.92	0.86	0.79	0.72	0.59	(0.54)
Departure from 9-year normal	.....	+0.09	+0.06	+0.05	+0.04	+0.07	+0.04	−0.02	−0.13	−0.16

TABLE 1.—*Solar radiation intensities during September, 1917*—Contd.

Madison, Wis.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Sept. 10	.....	.....	1.33	1.25	1.18	1.11	.....	.....	.....	.....
11	.....	1.37	1.31	1.24	1.18	.....	.....	.....	.....	.....
21	.....	1.25	.....	.....	.....	.....	.....	.....	.....	.....
22	.....	1.17	1.08	1.02	0.96	.....	.....	.....	.....	.....
24	.....	1.20	1.08	.....	.....	.....	.....	.....	.....	.....
29	.....	.....	1.26	1.12	.....	.....	.....	.....	.....	.....
Monthly means	.....	1.25	1.21	1.16	1.11	(1.11)	.....	.....	.....	.....
Departure from 8-year normal	.....	±0.00	+0.07	+0.12	+0.13	+0.18	.....	.....	.....	.....
P. M.										
Sept. 10	.....	1.42	1.30	1.23	1.16	.....	.....	.....	.....	.....
11	.....	1.37	1.29	1.23	.....	.....	.....	.....	.....	.....
21	.....	1.25	1.16	1.07	1.00	.....	.....	.....	.....	.....
22	.....	1.20	1.02	0.87	.....	.....	.....	.....	.....	.....
24	.....	1.20	0.98	0.79	.....	0.62	.....	.....	.....	.....
28	.....	1.27	1.20	1.07	0.94	0.84	.....	.....	.....	.....
29	.....	1.38	.....	.....	.....	.....	.....	.....	.....	.....
Monthly means	.....	1.30	1.16	1.04	1.03	(0.73)	.....	.....	.....	.....
Departure from 8-year normal	.....	+0.07	+0.05	+0.03	+0.04	±0.00	.....	.....	.....	.....

Lincoln, Nebr.

A. M.										
Sept. 5	.....	.....	.....	0.98	0.78	0.72	.....	.....	.....	.....
7	1.36	.....	.....	1.07	.....	.....	.....	.....	.....	.....
11	.....	1.16	.....	.....	.....	.....	.....	.....	.....	.....
13	.....	1.13	1.07	0.91	0.82	0.74	.....	.....	.....	.....
22	.....	1.17	1.02	0.89	0.76	.....	.....	.....	.....	.....
23	.....	1.24	1.15	1.07	0.97	0.86	0.80	0.73	.....	.....
24	.....	.....	.....	0.87	0.78	0.69	0.63	.....	.....	.....
27	.....	1.31	1.13	0.99	.....	0.86	.....	.....	.....	.....
28	.....	1.28	1.17	.....	.....	.....	.....	.....	.....	.....
29	.....	1.36	1.30	1.24	1.16	1.08	1.03	0.97	.....	.....
Monthly means	(1.36)	1.24	1.14	1.00	0.88	0.82	0.82	(0.85)	.....	.....
Departure from 3-year normal	+0.01	−0.03	±0.00	−0.01	−0.06	−0.03	+0.04	+0.15	.....	.....
P. M.										
Sept. 8	.....	.....	1.02	0.93	0.86	0.79	0.72	0.66	.....	0.58
13	.....	1.21	1.07	0.98	0.85	0.76	0.69	.....	.....	.....
17	.....	0.92	0.77	.....	.....	0.53	0.48	.....	.....	.....
18	.....	.....	0.94	.....	0.87	.....	.....	.....	.....	.....
21	.....	.....	.....	0.69	0.61	0.56	0.45	.....	.....	.....
22	.....	1.08	0.99	0.89	0.78	.....	.....	.....	.....	.....
23	.....	1.19	1.07	0.94	0.83	0.74	0.66	0.60	0.56	0.52
27	.....	1.33	1.25	1.17	1.10	1.03	0.97	0.91	0.86	.....
28	.....	1.27	.....	.....	.....	.....	.....	.....	.....	.....
29	.....	1.39	1.31	1.24	1.18	1.11	1.06	1.00	0.95	0.90
Monthly means	.....	1.20	1.05	0.98	0.88	0.79	0.72	0.79	0.79	0.67
Departure from 3-year normal	.....	−0.07	−0.08	−0.07	−0.06	−0.08	−0.09	+0.01	+0.06	+0.02

TABLE 1.—*Solor radiation intensities during September, 1917*—Contd.

Santa Fe, N. Mex.

Date.	Sun's zenith distance. 0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass. 1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Sept. 3	.....	.....	.....	1.18	1.11	1.06	1.00	.....	.....	.....
4	.....	.....	1.21	.....	1.13	1.09	1.02	0.96	0.91	.....
5	.....	1.37	1.24	1.17	1.10	1.04	0.98	0.92	0.87	0.82
6	1.45	1.32	.....	.....	.....	.....	.....	.....	.....	.....
7	.....	.....	.....	1.13	1.06	1.01	0.93	0.86	0.79	.....
12	.....	1.39	1.34	1.30	1.08	1.00	.....	.....	.....	.....
13	.....	1.37	1.28	.....	.....	.....	.....	.....	0.95	0.91
15	.....	.....	.....	.....	1.21	1.18	1.14	1.10	1.03	0.91
19	.....	.....	.....	.....	1.17	1.06	0.97	0.86	.....	.....
22	.....	1.44	1.32	1.26	1.20	1.14	1.08	1.02	0.97	0.93
Monthly means	(1.45)	1.38	1.88	1.21	1.13	1.07	1.02	0.95	0.92	0.89
Departure from 5-year normal	−0.06	−0.03	−0.03	−0.04	−0.03	−0.04	−0.03	−0.06	−0.04	−0.03
P. M.										
Sept. 28	.....	1.52	1.48	1.36	1.29	1.21	1.15	.....	.....	.....
Monthly means	.....	(1.52)	(1.48)	(1.36)	(1.29)	(1.21)	(1.15)	.....	.....	.....
Departure from 5-year normal	.....	+0.02	+0.07	+0.05	+0.09	+0.07	+0.07	.....	.....	.....

TABLE 2.—*Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Dates.	8 a.m.	8 p.m.	Dates.	8 a.m.	8 p.m.	Dates.	8 a.m.	8 p.m.	Dates.	8 a.m.	8 p.m.
1917.	*mm.*	*mm.*	1917.	*mm.*	*mm.*	1917.	*mm.*	*mm.*	1917.	*mm.*	*mm.*
Sept. 4	9.14	10.21	Sept.10	4.75	4.75	Sept.5	15.11	11.81	Sept.3	7.04	5.79
7	9.47	9.14	11	5.36	6.27	7	14.60	14.10	4	6.50	6.50
11	5.16	7.04	21	7.29	8.48	8	10.59	13.61	5	7.57	6.76
12	7.57	7.29	22	8.18	10.21	11	7.87	9.47	6	6.76	6.76
13	7.87	9.14	24	8.48	10.59	13	11.81	13.61	7	6.02	8.81
17	9.83	8.47	28	7.04	7.29	17	11.38	11.81	12	9.83	9.83
18	8.48	11.38	29	5.79	6.02	18	9.47	12.24	13	8.48	10.59
19	10.59	12.24	.....	.....	.....	21	9.83	9.47	15	4.75	5.56
22	10.97	7.87	.....	.....	.....	22	9.47	10.21	19	7.32	6.50
26	9.83	11.38	.....	.....	.....	23	7.87	9.14	22	7.32	6.76
						24	9.47	13.61	28	3.81	3.81
						27	5.79	6.50	.....	.....	.....
						28	5.16	7.29	.....	.....	.....
						29	6.27	5.16	.....	.....	.....

TABLE 3.—*Daily totals and departures of solar and sky radiation during September, 1917.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals. Washington.	Madison.	Departures from normal. Washington.	Madison.	Excess or deficiency since first of month. Washington.	Madison.
1917.	*calories.*	*calories.*	*calories.*	*calories.*	*calories.*	*calories.*
Sept. 1	195	330	−217	−64	−217	−64
2	362	452	−47	61	−264	−3
3	352	267	−55	−121	−319	−124
4	505	471	100	86	−219	−38
5	380	233	−23	−150	−242	−188
6	113	477	−288	98	−530	−90
7	319	53	−80	−321	−610	−411
8	50	429	−348	60	−958	−351
9	117	92	−279	−274	−1,237	−625
10	400	549	5	187	−1,232	−438
11	569	554	176	196	−1,056	−242
12	526	383	135	29	−921	−213
13	456	197	67	−152	−854	−365
14	238	403	−150	58	−1,004	−307
15	101	349	−285	7	−1,289	−300
16	273	413	−111	74	−1,400	−226
17	506	394	124	58	−1,276	−168
18	454	417	75	84	−1,201	−84
19	436	258	59	−71	−1,142	−155
20	337	99	−37	−226	−1,179	−381
Decade departure	.....	.....	.....	.....	53	57
21	316	436	−56	114	−1,235	−267
22	432	429	63	111	−1,172	−156
23	303	422	−64	107	−1,236	−49
24	216	414	−148	103	−1,384	54
25	243	394	−118	86	−1,502	140
26	429	94	71	−210	−1,431	−70
27	409	412	54	112	−1,397	42
28	208	419	−143	123	−1,520	165
29	336	412	−12	120	−1,532	285
30	435	310	91	22	−1,441	307
31	.....	.....	.....	.....	.....	.....
Decade departure	.....	.....	.....	.....	−262	688
Excess or deficiency since first of year. (calories	.....	.....	.....	.....	−5,981	1,680
Excess or deficiency since first of year. (per cent	.....	.....	.....	.....	−5.6	1.6

551.55 : 551.596

DÖPPLER'S PRINCIPLE FOR A WINDY ATMOSPHERE.

By HARRY BATEMAN, Ph. D.

[Dated: 730 South Lake Avenue, Pasadena, Cal., Oct. 15, 1917.]

In view of the interest which is being taken in the effect of wind on the propagation of sound it may be worth while to recall the form which Döppler's principle assumes when a wind is blowing.

If the observer is moving with velocity u, the source of sound with velocity v, and the wind with velocity V, all measured in the same direction, then in the case of sound waves moving in the opposite direction and originating at the source with frequency ν the observed frequency is

$$\nu_0 = \nu \frac{c - V + u}{c - V + v} \qquad (1)$$

where c is the velocity of sound in still air.

This result may be obtained with the ordinary form of Döppler's principle either by reducing the air to rest by substracting the wind velocity V from u and v, or by regarding the velocity of sound in the moving air as $c - V$.

To prove the formula analytically let us neglect the variation of air-density and wind-velocity with altitude and assume that the wind is blowing steadily in a direction parallel to the axis of x with velocity V, then the velocity potential ϕ of sound waves propagated through the air satisfies the partial differential equation.[1]

$$\left(\frac{\partial}{\partial t} + V\frac{\partial}{\partial x}\right)^2 \phi = c^2 \nabla^2 \phi.$$

This equation may be transformed into the ordinary wave-equation for still air by writing x' in place of $x - Vt$. The solution corresponding to sound from a moving source which is at the point $\xi(\tau)$, $\eta(\tau)$, $\zeta(\tau)$ at time τ is

$$\phi = \frac{1}{\gamma} f(\tau)$$

where τ is defined by the equation

$$[x - \xi(\tau) - V(t - \tau)]^2 + [y - \eta(\tau)]^2 + [z - \zeta(\tau)]^2 = c^2 (t - \tau)^2,$$

and γ is the partial derivative of the left-hand side with respect to τ.

Putting

$$x = a + ut,\ y = 0,\ z = 0,\ \xi(\tau) = \alpha + v\tau,\ \eta(\tau) = 0,\ \zeta(\tau) = 0,$$

where a, α, u, v, are constants so as to have the case of a source and observer moving along the same straight line with different constant velocities, we find that

$$\tau = \frac{t(u - v \pm c) + a - \alpha}{v - V \pm c}$$

For sound of frequency ν we may write $f(\tau) = A\sin(\nu\tau + \epsilon)$ and the observed frequency is seen to be given by formula (1). The wave-length is also

$$\lambda_0 = \frac{2\pi}{\nu}(\pm c - V + v)$$

It should be noticed that if $u = v$ the observed frequency is the same as the natural frequency whatever be the velocity of the wind. If $v = V$ the observed wave-length is the same as the natural wave-length. In actual practice the horizontal wind velocity may be different at the locations of the source and observer owing to vertical motion of the air, eddy motion, and friction. An exact mathematical treatment of the general problem is difficult

[1] See, for instance, *S. Fujiwhara*, in Bull., Central meteorol. obs'y, Japan, Tokyo, (1912), 2, no. 1.